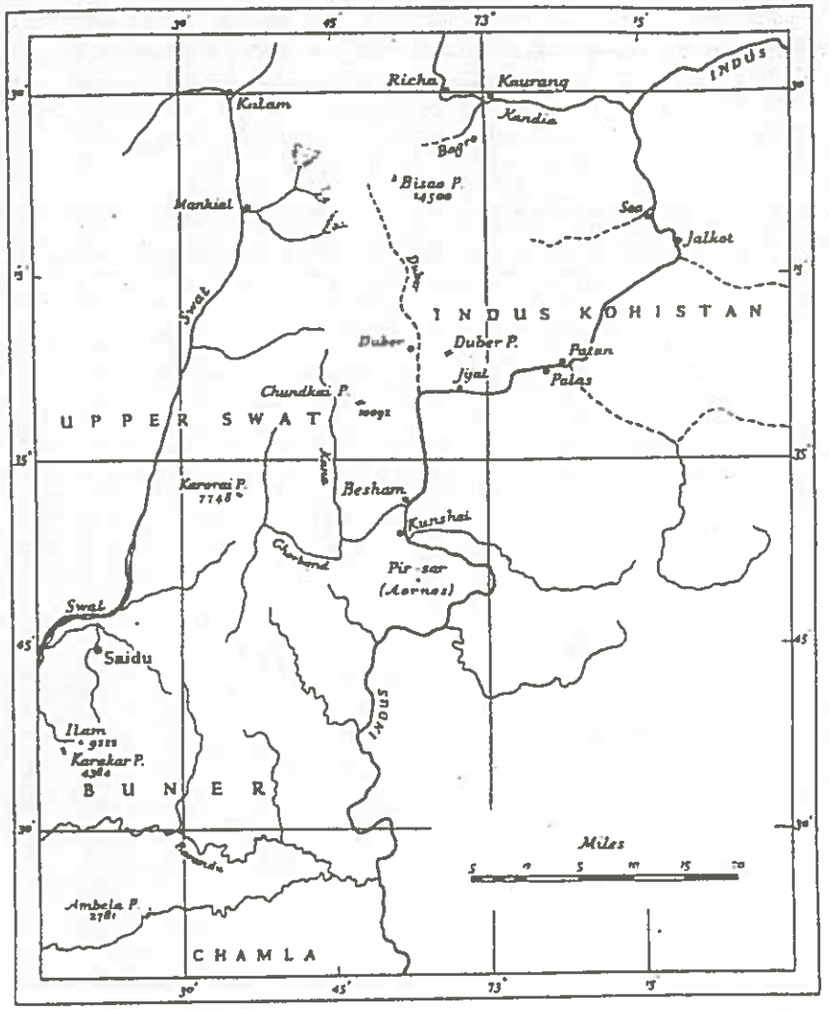
Gul-shahzada Abdul Wadud Sahib, having completed the annexation of the Indus Kohistan east of the Indus in 1939.

My recent expedition started from Swat and was carried out under the auspices of its ruler. So I may refer here briefly to what my renewed visit to the State he created has shown me of the results achieved there by his rule.



Swat is a large mountain territory very fertile in its main portion and blessed with many favours of nature. The old Chinese pilgrims have much to tell about the prosperity of the country, the many Buddhist sanctuaries and monastic establishments maintained by its population. But after the invasion of the White Huns in the sixth century A.D. a decline set in. Since its conquest by Pathan tribes and probably also earlier in Muhammadan times Swat never ceased to suffer from internal feuds uncontrolled by any central authority.

In the famous Akhun of Swat a great religious leader arose in the first half of the last century. He was able to unite the tribes in fanatical resistance to the Sikhs and later to the British regime on the Frontier. But internal disorder remained and exposed Swat to aggresion by powerful neighbouring chiefs. It was only since the present Wali, a grandson of the great Akhun, had established his control over all the tribal factions, and after prolonged struggles had overcome outside aggression, that Swat has enjoyed peace and order. Under the old Pathan custom all lands held by a tribal sub-section or clan had to be divided afresh every four or five years among all the tribesmen. This custom would not allow of any lasting improvement of the land, such as planting fruit trees, for which Swat is suited. It required wise statecraft and persistent effort to stop this traditional system and replace it by individual holdings. Now I could see everywhere flourishing orchards and other improvements as I passed up the road last October to the Wali's capital, Saidu Sharif, where his grandfather's sacred tomb stands.

From the start the Wali had realized the importance of roads both for trade and military operations. So by 1926 I had already found regular mule-paths made under his orders up the main valleys and over the hill ranges between them. Now I found regular motor roads leading up the main Swat Valley and across the large tract of Buner south of it. A very noticeable increase in the number of shops, in the traffic along the roads, and the growth of some villages into something like market towns afforded striking proof of the benefits which security and peace established under a strong rule had brought to a once turbulent country. It was reassuring to find that so much material advance had been secured without changing the simple methods of an administration based on traditional customs, and as regards justice on Islamic law.

The Wali, though now well above middle age, is still as alert and hard-working as I remembered him. He is quite illiterate. But great personal ability coupled with a remarkable memory and wise trust in two very experienced ministers, brothers and supporters in his initial struggles, enable the Wali to direct all affairs. Telephone lines to the most distant posts permit him to gather information and give orders. He has never failed to maintain very cordial relations with Government on the Frontier.

In the summer of 1939 the Wali, after careful preparation, rounded off his dominion by the occupation of the Kohistan valleys between uppermost Swat and the Indus. The difficulty of access and to some extent the barrenness of the ground had kept Pathan tribal settlement away from the Kohistan and allowed the original population of Dard race and speech to survive there. But just as before in Swat, insecurity and internal disorder had caused the scanty population to remain in a very backward condition.

After this last extension of the Wali's rule Colonel W. R. Hay, then Political Agent for Dir, Swat, and Chitral, informed me that the opportunity for exploration in the Indus Kohistan had come within my reach. When after my return to India in 1939 I learned that the Wali desired a postponement of my expedition I did not feel discouraged, for I knew that the goodwill

and judgment of my old patron could be trusted. Last September I learned that the Wali was now prepared to let me start after the Ramzan, the month of Muslim fasting, had passed by the close of October. That area had remained the only practically unsurveyed ground along the whole course of the Indus from Tibet to the Arabian Sea. So Brigadier E. O. Wheeler, Surveyor-General of India, readily agreed to depute with me Surveyor Muhammad Ayub Khan, who had been my survey assistant on all my four Persian expeditions.

A few days' stay at Peshawar under the hospitable roof of Government House allowed me to thank Sir George Cunningham, Governor of the N.W. Frontier Province, for the friendly interest and help with which he has as always furthered my plans. On the Malakand I could thank Colonel E. G. Mallam for what he had done as Political Agent to smooth my way. At Saidu, the capital of the Swat State, I received the kindest welcome from the Wali. A motor drive of some 120 miles across the Karakar pass and the wide tracts of Buner and Chamla allowed me to visit again the famous Ambela pass.

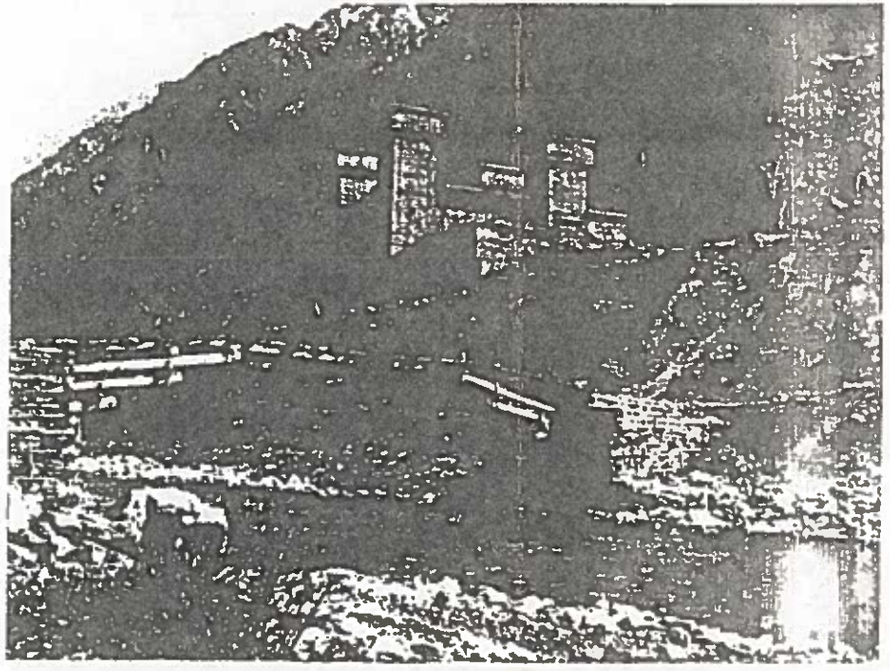
On October 30 I started with my little party for the Indus Kohistan. The route led up the Kana valley down which I had passed in 1926 on my way to Alexander's Aornos. To reach its mouth by a motor road just completed saved what at that time would have meant a week's travel. On the way up the Kana valley and for two marches beyond it was still possible to use mule transport. But farther on during nearly three months' travel we had to depend on porters and our own feet. It was pleasant to find my passage still well remembered by the old Khans of Kana.

Then from the head of the Kana valley overlooked by high snowy peaks the ascent led to the Chundakai pass. On its top, about 10,000 feet above sea, we were received by Hakim Abdul Qudus, Governor of the Kohistan, who was to accompany us through our difficult travels. It was due mainly to his unfailingly careful arrangements that all the physical difficulties were successfully overcome.

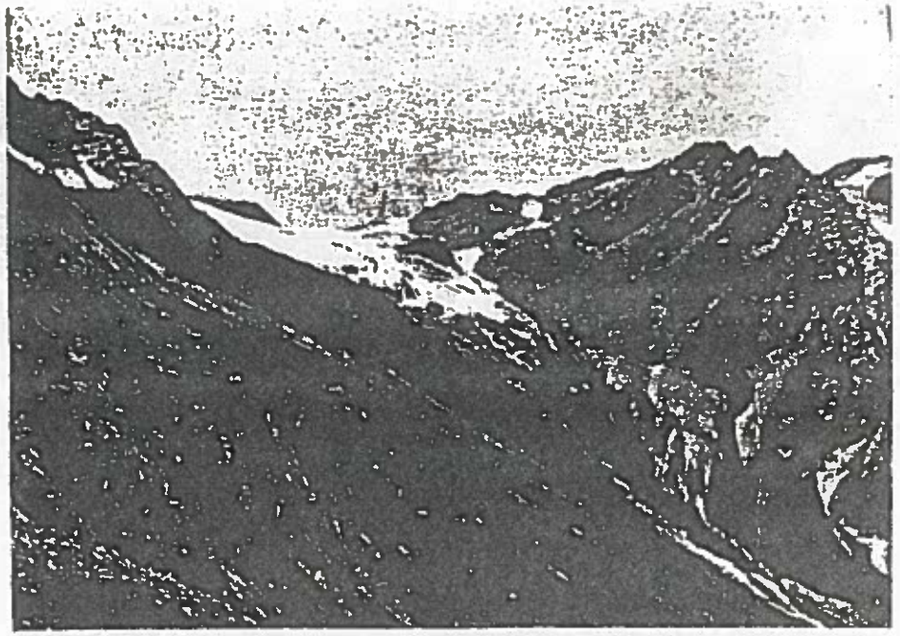
The route chosen for the first marches led along high alps at the head of very narrow valleys descending steeply towards the Indus. From camps near the tree limit it was possible to climb several high spurs, which provided excellent stations for the exact plane-table survey carried along the whole of our journey. They commanded distant views to the north-east and eastward across the Indus valley and beyond it as far as the snowy ranges which divide the Kohistan from Kaghan and Kashmir territory. But the great river in its deep gorges was completely hidden.

When our route had led us down into the side valley of Duber our camp was pitched for the first time under the walls of one of those picturesque timber and rubble-built forts which shelter the Wali's small garrisons in the Kohistan as elsewhere in the State. By their uniform plan they curiously recalled to me those ancient Roman *castella* by which the Roman Empire for centuries guarded the *Limes* routes on its Near-Eastern frontier. The Wali's men-at-arms holding those forts assure order in a previously lawless country. The men as well as their officers and the few local officials are all paid in kind from the *ushar* or land tax, amounting to one-tenth of the actual produce.

The Wali of Swat at Saidu



Gabrial fort and Kandia river



Glacier on range south-east of Bisao pass

Towards Bisao pass from Lal Bek

Such an impost, spent almost wholly in the valleys where it is levied, does not weigh heavily on the local population, poor as it is. The cultivable ground all through the Kohistan is extremely limited; hence its people depend far more on their cattle and goats.

From Duber it was necessary to gain the Kandia valley northward, the only side valley of any size. The Bisao pass, which gives access to it, was likely soon to be closed by snow. It was crossed just in time, but proved trying. After a long march had brought us to the highest of the huts to which the Duber people, like all the others of the Kohistan, repair in the summer for grazing, it took us a day and a half of exacting climbing before the height of the pass was gained. The ascent on the first day lay over a succession of old glacier beds and moraines. The recession of glacier ice, apparently not very distant in geological time, had left here huge masses of rock debris in utter confusion, very trying to the feet, especially to mine, which had lost many toes from frostbite thirty-four years before on the high Kun-lun range. It was long after darkness had set in that the narrow rocky ridge was gained where room could be found for a night's halt.

The morning light revealed an amphitheatre of rugged peaks crowned with *névé* beds and small hanging glaciers. The Bisao pass is formed by the knife-edge *arête* of a rocky spur running down steeply from a great massif with peaks close on 19,000 feet high. In order to gain our way to it we had to scramble up a long series of old terminal moraines. They looked like huge steps laid down by a former great ice flow. From the pass for which aneroid and clinometer observations indicated an approximate height of some 14,500 feet, a wide snowy trough was seen to descend northward. The descent in soft snow hiding detached masses of rock was necessarily slow. So it was quite dark by the time the head of a steep and narrow ravine was gained in which the further descent had to be made. The sides of the ravine were covered with deep snow, and the descent along a very precipitous slope in the light of a lantern looked risky. By the time it had been safely accomplished Surveyor Muhammad Ayub and myself had been six hours in the snow. Three more hours were needed to bring us to the first place where it was possible to camp with some shelter for the load-carrying men. By then it was one hour after midnight.

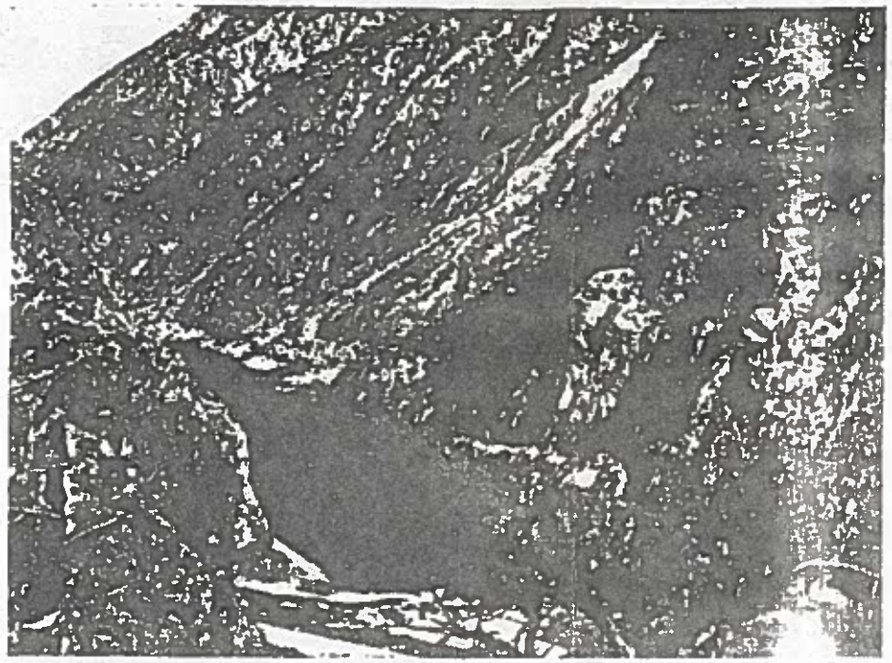
After that long day's experience the three marches which took us down the Bagro valley to the Kandia river seemed delightfully easy. But we had not yet covered the second when fresh snow was seen falling on the high mountains above. It meant the closing of the Bisao pass until the next summer. At the little village and fort of Karang in the centre of the Kandia valley a halt was imposed partly by survey work and partly by the illness of one of my two old Kashmiri servants. At first it looked serious. But Surveyor Muhammad Ayub was able to proceed up the head of the Kandia valley and in spite of trying climatic conditions to check his position by observation to distant triangulated peaks. Once assured about my servant's condition I followed him to the last small village of Kandia. In ascending the deep-cut gorges of the river difficult cliffs rising high above the rock-bound bed had to be negotiated. As at Karang, so also at the hamlet of Richa I found that old mosques in the designs of their wood-carving showed motifs unmis-

takably derived from the style of Graeco-Buddhist sculpture. It was impressive evidence that the influence of Hellenistic art had penetrated into this far-off mountain region in spite of the very rude conditions of life there.

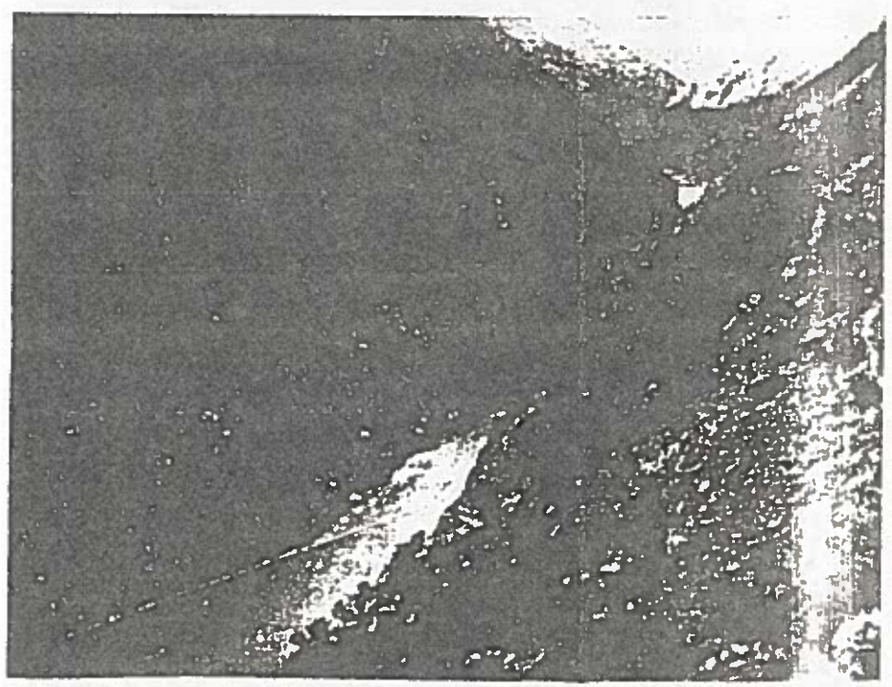
From the head of the Kandia valley we turned back to reach the gorges of the Indus. But before we arrived there bad weather with rain and snow overtook us at the fort of Tuti which guards the approach from the Tangir side. It was a bad place to get weather-bound in. The Kandia valley is there so narrow that Tuti is never reached by the sun for three months of the winter. Fortunately it was possible to use such enforced halts for some record of specimens of the little-known Kohistani language. It belongs to that Dardic branch of the Indo-Iranian language group which is now confined to Hindukush valleys but in earlier times was spoken much farther down the Indus. How the tribes still speaking Dardic languages came to occupy these high mountain tracts is an interesting problem. For its elucidation anthropological evidence is much needed. In order to help towards securing it anthropological measurements and observations were taken on a considerable number of Kohistanis in the course of my journey.

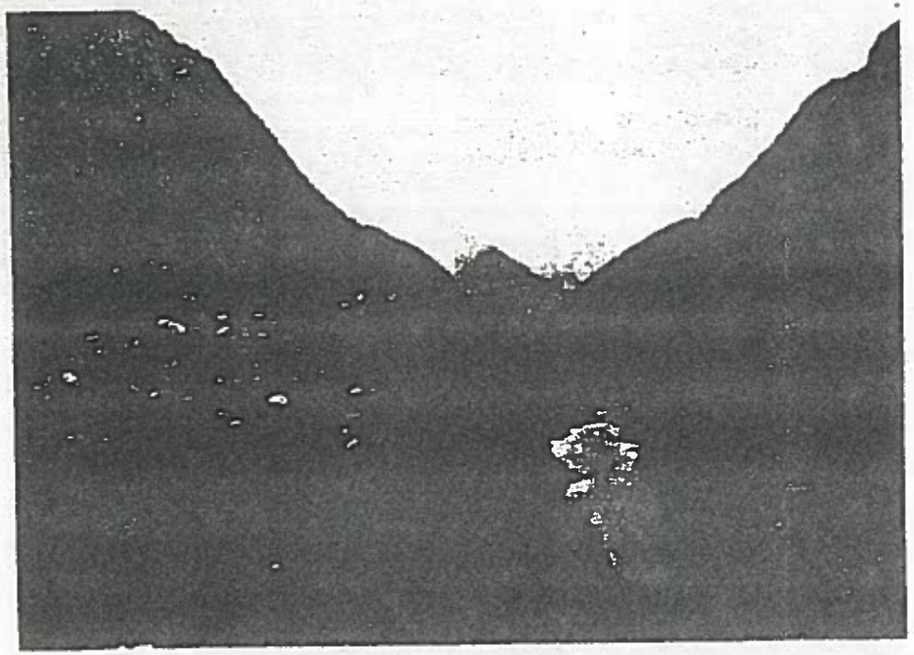
On December 11 at last we could leave gloomy Tuti and descend the Kandia valley to the Indus. For a couple of miles the difficult track lay mostly over galleries clinging to sheer rock faces and supported by tree branches, before the first view of the Indus was gained from a height of some 1000 feet above where the Kandia river joins it: the Indus a narrow band of intense ultramarine green confined to a rock-bound bed between precipitous mountain sides. The track which had brought us to this point, and which we were to follow farther on, had been much improved under the Wali's orders since the occupation of the Kohistan, and for this great credit was due to the Hakim. Even thus it has remained difficult enough and quite impracticable for any laden animal. On the opposite left side of the river the track still in use by the people living east of the Indus clings in places to bare rock walls along narrow ledges, with tree trunks serving as ladders to connect them.

That early Chinese pilgrim, Fa-hsien, has described the forbidding route he and his pious fellow travellers had followed in A.D. 400, after leaving Ta-li-lo, the present Darel. In Professor Giles' translation it runs: "Keeping to the range, the party journeyed on in a south-westerly direction for fifteen days over a difficult, precipitous and dangerous road, the side of the mountain being like a stone wall ten thousand feet in height. On nearing the edge, the eye becomes confused; and wishing to advance, the foot finds no resting place. Below there is a river, named Indus. The men of former times had cut away the rock to make a way down, and had placed ladders on the side of the rock. There are seven hundred rock steps in all; and when these and the ladders have been negotiated, the river is crossed by a suspension bridge of ropes. The two banks of the river are somewhat less than eighty paces apart. . . . Having crossed the river, the pilgrims arrived in the country of Udyana (Swat) which lies due north of India." This description is now fully confirmed by our survey. We have here one more proof how much reliance can be placed on the topographical sense and power of observation of those old Chinese travellers on whose records the historical geography of India so largely depends.

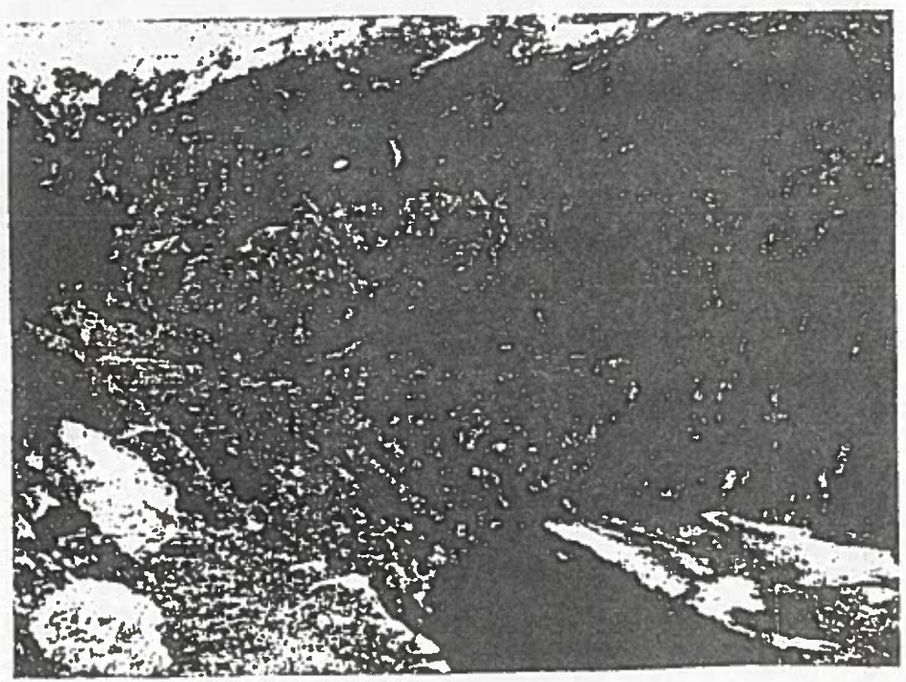


Indus at confluence with Kandia





Indus above Patan



Indus near Kunshai

Our progress down the Indus during the next few weeks showed only too clearly what was meant by Fa-hsien's reference to those many "rock steps," as the translation puts it. On all the eleven trying marches which took us down to where we turned off from the Indus to follow the route up the Ghorband valley to Swat, there was daily a constant succession of tiring ascents to be made. The track climbs up steeply ridge after ridge, each rising sometimes as much as 1000 feet or more above the river, in order to avoid impassable cliffs. From the heights thus gained there were invariably descents, often quite as tiring, to be made again towards the river. Nowhere was it possible to keep for any distance near to the river bank since masses of huge boulders line it wherever the river does not actually wash the foot of impassable rock walls. I have not counted all the climbs, but they must have been still more numerous before the recent track was constructed. When this was being made the men had often to be suspended from pegs while they were at work boring holes to blast the rock or to fix in fissures the tree branches which were to support galleries.

This is not the place to give details of the arduous marches which carried us down the Indus to where the great river leaves its gorges. In comparing the number of our eleven marches with the fifteen counted by Fa-hsien it must be remembered that his reckoning starts from the mouth of the Darel valley, at least 30 miles higher up than that of the Kandia valley.

Throughout the Kohistan the route along either bank of the Indus retains its very trying character. Only at a couple of places, at Sio and Patan on the right bank and Jalkot and Palas on the left, alluvial fans, small in size, leave room enough for settlements deserving to be called villages. But owing to the great summer heat of the narrow Indus valley even these villages with their closely packed rows of low rubble-built dwellings are occupied only during the cold weather months. For the rest of the year their inhabitants retire with their cattle and goats to huts on high grazing grounds.

It is the same with the few hamlets to be found at rare intervals along the river. The mountain sides to which their dwellings and small terraced fields cling, everywhere hundreds of feet above the Indus, are so steep that patches of flat ground for pitching our little tents could be found only with difficulty. The conditions of life among the scanty population, with its extremely limited economic resources, could not have been very different in ancient times. At the few old village sites reported the ruined dwellings examined proved as rude in construction as those inhabited at the present day. Yet the great size of the trees, mainly Ilex, growing over the ruined walls proves considerable age for the occupation of these sites.

Owing to the depth and extreme narrowness of the valley in which the Indus has cut its bed through the mountains, it was not possible from our route to sight any high peaks already fixed by triangulation over great distances, but at last Muhammad Ayub, ascending the side valley of Patan to the highest of the summer huts, reached from there positions on high snow-covered spurs which could be fixed on the plane-table; the position thence deduced for the fort at Patan was less than a mile and a half from that previously indicated by his traverse.

These survey operations and other tasks had necessitated a longer halt

at [illegible] headquarters there; but it subsequently caused us to be overtaken again by bad weather conditions at two further stages down the Indus. At the fort of Jijal the days of continuous rain mingling with snow were distinctly trying, for the terrace specially raised to provide some level space for our little camp was soon turned into the semblance of a morass, threatening to glide down the steep slope.

Near Sio and at a few points lower down the width of the great river could not much exceed 40 or 50 yards. Near Sio and again below it near the village of Jalkot on the left bank we were shown places where the Indus had been spanned by rough wooden bridges in quite recent times. The great depth of the water in the narrow bed, even in its reduced winter flow, accounts for the beautiful green colour throughout its course, except where rapids break in white waves. The great height and much increased width to which the river rises during the floods of the spring and summer could be judged by the water-worn appearance of the cliffs and the huge boulders to be seen on either side high above the narrow rock-bound bed.

By the third week of January we emerged near Besham on ground already mapped by the Survey of India at the mouth of the Ghorband valley. Only a couple of miles below must have been that rope bridge crossed by Fa-hsien and his fellow pilgrims. There close to the village of Kunshai the Indus flows in a rock-lined bed about 80 yards wide, closely adjoined on either side by steep equal eminences high enough to allow the rope bridge to hang well above the river even when in flood. On the rocky ridge of the right bank are remains of an ancient watch post to guard the bridge and the passage.

Here our exploration came to its end, but not yet the difficulties of travel. The Ghorband valley farther up was under snow right down to its bottom, and when after three marches we had approached its head the Karorai pass covered with exceptionally heavy snow presented a serious obstacle. But plentiful local help and a favourable turn of the weather allowed us to cross the pass safely, though not without some difficulty. Then the wide open Swat valley lay before us, and soon after being very hospitably welcomed at the Wali's residence I could thank my old patron once again for all that his unfailing support had allowed me to do and enjoy in pursuit of a long-cherished plan.

The sketch-map to show the outline of this journey has been made from Survey of India Half-inch sheet 43 F/NW, Quarter-inch sheets 43 A, B, and E, and 1/M sheet 43 dated 1935, 21, 34, 35, and 30 respectively: the latest we have in our collection. It cannot show all the names mentioned by the author because some are not on these maps. Where his spelling differs from the Survey maps we have retained his spelling in the text, and left the Survey spelling on the sketch-map. Sheet 43 B shows a number of unmetalled roads and tracks as "fair weather motor roads," but it is not possible to select those which have now been improved and made the main road to Saidu, the route of the author's trip to the Ambela pass, or the road north and east of Saidu to the Kana valley.

PLOTTER AND CRONE'S GRAPHICAL SOLUTION

CAPTAIN L. G. TROREY, R. Canadian Engineers

Meeting of the Society, 8 December 1941

PEOPLE who have any connection with air survey, particularly with the photogrammetric end, seem to become affected in much the same way as are users of habit-forming drugs. These unfortunate persons can be recognized in the early stages of their affliction by a peculiar glitter in the eye. They say it is due to long hours of peering into stereoscopes, and so on. But that is not the truth. It is the first symptom that the photogrammetric virus is at work. In later stages these people have an irresistible impulse to read a technical paper, and in really serious cases they design a photogrammetric instrument. For these reasons, in the technique of the art of photogrammetry there are more hard ways of doing easy things than in any other branch of human endeavour.

Two exceptions which go to prove the foregoing rule are the Crone Graphical Construction, and the Burns High Oblique Plotter. In previous times the surveyor used to climb mountains, often with considerable exertion, and then sit on the mountain top waiting for the weather to clear so that he could take observations. Later, he used a combination of theodolite and camera, but still had to climb the mountain with it. Now he flies, takes some pictures, and does the observing comfortably in his office. Still better, he sends someone else to take the pictures, and does not go out at all.

The High Oblique Plotter and the Crone method do all that could be done if you imagine some means of holding a plane still in space while you set up a theodolite on it and make the observations. There are two limits to bear in mind: the field of view is that of the camera, and the accuracy of a precise theodolite would not be expected.

Air survey photographs

Air photographs may be taken with the camera axis pointed vertically downward, in which case the picture, under certain conditions, approaches to being a true plan of the ground below. These are verticals, and are familiar nowadays to most people.

If the camera axis be deliberately pointed off the vertical, an oblique photograph results. High Obliques are those in which the horizon appears, or nearly appears. Horizon Obliques is a better name. When the inclination of the optical axis to the vertical is less than that required to contain the horizon, but too great for the picture to be treated as a vertical, there results a Low Oblique. Low obliques, particularly those just too tilted to be called vertical, are also referred to as Near Verticals.

Verticals and near verticals require to be controlled; that is to say we like to know the map position, and the elevation, of several points on each picture, or at any rate several points on the flight. From horizon obliques we may obtain the azimuth from the plumb point (the point immediately below the